



Manitoba
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and Workplace
Safety and Health



AMBIENT SULPHUR DIOXIDE
LEVELS IN THE VICINITY
OF CANADA METALS CO. LTD.,
WINNIPEG, MANITOBA
1984

by

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ABSTRACT

In response to odour complaints received by the Air Pollution Control Section of the Environmental Management Division, Province of Manitoba and the Environmental Protection Branch of Environment Canada, the Mobile Monitoring Unit was diverted from a previously scheduled project in the same vicinity to monitor sulphur dioxide levels in the area of Canada Metals Co. Ltd., 1221 St. James Street.

Results of this study indicate that sulphur dioxide levels fall below the maximum acceptable level of 0.34 ppm averaged over one hour, as set out in the Manitoba Air Quality Objectives. The maximum desirable level of 0.17 ppm averaged over a one hour period was exceeded in some cases.

Some samples were also taken for sulphuric acid mist. None of the samples were found to exceed the proposed standard of 100 $\mu\text{g}/\text{m}^3$ averaged over a one hour period.

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1. BACKGROUND

Canada Metal Co. Ltd., 1221 St. James Street, Winnipeg, is a secondary lead smelter, refining scrap lead into lead ingots. A reverberatory furnace, consisting of a large refractory lined chamber with a burner at one end, is used to melt and and purify the lead, which is mainly used battery plates and lead drosses.

A conveyor is used to transfer the scrap to the furnace, which is charged continuously with approximately 450 kg of scrap. Molten lead is continuously tapped from the furnace, and may be further refined on-site. The slag is periodically tapped off and is not normally processed any further at the plant.

Exhaust gases are passed through two cooling towers and are directed into a baghouse. Dust collected by the baghouse is returned to the furnace via a screw conveyor. Exhaust gases are then released from the baghouse through a 104 cm diameter 19.8 m stack.

Significant emissions may be produced as a by-product of the lead smelting process. These include sulphuric acid mist, which is formed from sulphuric acid and lead sulphate remaining on the battery plates during furnace charging, and sulphur dioxide, which is formed as a breakdown product of sulphuric acid and lead sulphate at high temperatures.

In response to odour complaints received by the Air Pollution Control section of the Province of Manitoba Environmental Management Division and the Environmental Protection Branch of Environment Canada, a survey was undertaken utilizing the Mobile Monitoring Unit downwind of the plant. Sampling was performed as meteorological conditions permitted, and as access to affected areas allowed.

Specific objectives of this study were:

1. To determine ambient ground level concentrations of sulphur dioxide and sulphuric acid mist in the vicinity of the plant.
2. To compare concentration levels to Manitoba Ambient Air Quality Objectives/Guidelines.

The following sections summarize the applicable air quality objectives, sampling and monitoring procedures used, results and a discussion of data obtained.

2. MANITOBA AIR QUALITY OBJECTIVES AND GUIDELINES

Manitoba Air Quality Objectives and Guidelines have been formulated for various air pollutants. The objectives for sulphur dioxide (see Table 1) have been adopted from the National Air Quality Objectives. Sulphuric acid mist guidelines are currently under review, and have not been promulgated at this time.

The provincial criteria have been established for two levels:

Maximum Acceptable Level (MAL) - This level is intended to provide adequate protection against effects on soil, water, vegetation, materials, animals, visibility, personal comfort and well being.

Maximum Desirable Level (MDL) - This level defines long term goals for air quality and provides a basis for anti-degradation policy for the unpolluted parts of the province for the continuing development of control technology.

2.1 Sulphur Dioxide

Background levels of sulphur dioxide in the atmosphere have been determined as 4 micrograms per cubic metre ($\mu\text{g}/\text{m}^3$) or less, and no current evidence indicates that these levels can cause harm to the environment (1). Levels well in excess of background concentrations can, however, have a deleterious effect on vegetation and human health.

The maximum acceptable levels have been determined on the basis of the following considerations:

Levels of less than $900 \mu\text{g}/\text{m}^3$ (0.34 ppm) averaged for one hour will help prevent discomfort to sensitive individuals, with respect to taste and odour, and will prevent the persistence of concentrations of SO_2 for several hours, which has the potential to injure vegetation.

Levels of less than $300 \mu\text{g}/\text{m}^3$ (0.11 ppm) averaged over 24 hours will help prevent health effects, while levels of less than $60 \mu\text{g}/\text{m}^3$ (0.02 ppm) averaged over one year will minimize chronic effects in forests.

The maximum desirable levels have been justified on the basis of being at or below the threshold of very slight human effects and very slight chronic effects to forests.

2.2 Sulphuric Acid Mist

Sulphuric acid mist in the atmosphere has been determined to have a deleterious effect on ecological systems, damaging vegetation and killing certain animal species⁽²⁾. This compound is also found to cause corrosion of metals and leaching of construction materials such as limestone and marble. However, the most important effect of sulphuric acid is in the area of human health, with studies indicating that continued exposure causes increased resistance to pulmonary flow and suppressed central nervous system response.

Proposed guidelines for a maximum acceptable ambient level for sulphuric acid mist are set at $100 \mu\text{g}/\text{m}^3$ based upon a one hour time weighted average.

TABLE 1 - AMBIENT AIR QUALITY CRITERIA

<u>CONTAMINANT</u>	<u>AVERAGING</u>	<u>MAX. DESIRABLE</u>	<u>MAX. ACCEPTABLE</u>
	<u>PERIOD</u>	<u>LEVEL</u>	<u>LEVEL</u>
Sulphur Dioxide	1-hour	450 (0.17)	900 (0.34)
	24-hour	150 (0.06)	300 (0.11)
	Annual	30 (0.01)	60 (0.02)
Sulphuric Acid Mist	1 hour		100*

Concentrations are expressed in units of micrograms of contaminant per cubic meter ($\mu\text{g}/\text{m}^3$) of air corrected to standard conditions of 25°C and 101.3 kilopascals of pressure. The part per million - ppm - (by volume) equivalent concentrations are given in parentheses.

* Proposed Limit

3. PROCEDURES

3.1 Sulphur Dioxide (SO₂)

Monitoring for sulphur dioxide was performed using a Thermo Electron Model 43 pulsed fluorescence ambient SO₂ analyzer. Pulsating ultraviolet light is focused through a narrow bandpass filter into a fluorescence chamber. Sulphur dioxide molecules are excited to a higher energy state in the chamber then give off a decay radiation (light) characteristic for SO₂. This radiation is allowed to pass selectively through a second filter to impinge on a photomultiplier tube. The light emissions are processed electronically, such that the light energy is converted into a voltage signal which is proportional to the concentration of sulphur dioxide in the sample being analyzed. This method is highly specific, with few interferences.

3.2 Sulphuric Acid Mist

Monitoring was undertaken for sulphuric acid mist, using NIOSH method P&CAM 187⁽³⁾. A sequential sampling system was used to draw ambient air at a rate of 1.5 L/min over a period of one hour, through an impinger system containing distilled water. Samples collected were submitted to the W. M. Ward technical Services Laboratory for analysis of total sulphate concentration. This parameter has been used in a number of jurisdictions ^(4,5,6) for establishment of ambient sulphuric acid concentrations.

3.3 Wind Speed and Direction

Wind speed and direction were obtained from an on-board meteorological tower. The tower with a Windflo 540 wind speed and direction sensing instrument, manufactured by the Athabasca Research Corporation Ltd., was raised to a 10 metre height. Wind speeds were recorded on strip charts during the monitoring program. The output from the anemometer is a voltage, and was converted to appropriate engineering units (i.e. km/hr). The same principle applied to the wind direction. Directions are given relative to true north taking into account the magnetic declination of approximately 6° east in the vicinity of Winnipeg.

4. MONITORING SITES

Monitoring was conducted at three sites during the course of the survey. All locations were 0.5 km or less from the Canada Metals plant.

A detailed site description of each location accompanies Map 1⁽⁷⁾ in Appendix A.

5. RESULTS

Hourly averaged concentrations for sulphur dioxide and sulphuric acid mist measured at each sampling site are shown in Table 2. Corresponding wind speed and directions measured on site and operator general comments are also included.

Hourly averages were calculated for sulphur dioxide using 12-5 minute average concentrations obtained by visual averaging of the strip chart record. Acid mist concentrations were calculated based upon total sulphate concentrations measured from analyzed samples submitted to the W. M. Ward Technical Services Laboratory.

A summary of sampling duration and average concentrations of sulphur dioxide and sulphuric acid mist are shown for each site in Table 4. Survey data is further summarized for comparison of downwind versus background levels in table 4.

TABLE 2 - MONITORING RESULTS CANADA METALS

Date & Time	Site No.	SO ₂ conc. (ppm) 1 hr TWA	H ₂ SO ₄ conc. µg/m ³	Wind Speed (km/hr)	Wind Direction (degrees)
Apr. 4/84					
10:00-11:00	1	.10	<30	Calm (<5km/hr)	210
11:00-12:00		.15	<30	12	230
12:00-13:00		.09	<30	13	230
13:00-14:00		.16	<30	11	240
Apr. 5/84					
12:00-13:00	2	.06		14	170
13:00-14:00		.19		16	170
14:00-15:00		.07		14	160
15:00-16:00		.02		16	150
16:00-17:00		.09		16	150
17:00-18:00		.03		16	150
18:00-19:00		.01		13	150
19:00-20:00		.03		15	150
20:00-21:00		<.01		15	150
21:00-22:00		.02		14	150
22:00-23:00		.02		12	150
23:00-24:00		.02		15	150
Apr. 6/84					
24:00-1:00	2	.02		17	150
1:00-2:00		.05		14	150
2:00-3:00		.04		14	150
3:00-4:00		.05		14	140
4:00-5:00		.01		10	140
5:00-6:00		.03		11	140
6:00-7:00		.24		13	180
7:00-8:00		.06		13	150
8:00-9:00				14	150
9:00-10:00				16	160
10:00-11:00	3	.10	<30	20	170
11:00-12:00		.16	45	23	140
12:00-13:00		.04	<30	23	130
13:00-14:00		.17	<30	23	130

TABLE 3 - SURVEY DATA SUMMARY (a)

Site No.	Times and Date	No. of Hours	Average Conc.	
			SO ₂ (ppm)	H ₂ SO ₄ (μ g/m ³)
1	10:00 4/4/84-14:00 4/4/84	4	0.12	<30
2	12:00 5/4/84-10:00 6/4/84	20	0.05	
3	11:00 6/4/84-14:00 6/4/84	4	0.12	<30

TABLE 4 - SURVEY DATA SUMMARY (b)

	SO ₂	H ₂ SO ₄
Total No. of Monitoring Hours	28	8
Downwind Monitoring (hrs)	12	8
% of Total	42.9%	
Average Concentration (ppm)	0.09	<30
Background (not downwind) Monitoring	16	
% of Total	57.1%	
Average Concentration	0.03	

DISCUSSION:

Monitoring for this survey was performed over a three day period April 4-6, 1984. Meteorological conditions were characterized by moderate winds (10-20 km/hr) which shifted constantly, and cool temperatures. Light, visible emissions were observed from the stack, and an odour characteristic of sulphur compounds could be detected in the vicinity of the MMU, when in a downwind venue from the plant. No exceedances of the twenty four hour maximum acceptable limits were recorded during the course of the survey. However, the sulphur dioxide concentration was found to exceed the one hour maximum desirable limit concentration on three occasions (Apr. 5 13:00 .19 ppm, Apr. 6 6:00 .24 ppm and 13:00 0.17 ppm) when the MMU was downwind of the plant.

No exceedances of the proposed maximum acceptable level for sulphuric acid mist were recorded.

This survey was initiated in response to odour complaints received by both the Environmental Protection Branch of Environment Canada, and the Air Pollution Control Section of the Province of Manitoba Environmental Management Division. While on-site, MMU personnel could physically detect odours characteristic of sulphur gases when in a downwind venue from the plant. Reference sources have set the lower odour threshold for sulphur dioxide between 0.47 and 0.50 ppm^(8,9), which is above the MAQO maximum acceptable limit of 0.34 ppm averaged over a one hour period. Monitoring results are analyzed based upon time weighted averages. This type of averaging is very sensitive to variable wind conditions, which can cause large fluctuations of ambient contaminant readings over a short period of

time. This type of situation was encountered during the first part of the survey, with the plume fanning back and forth through the sampling area. Therefore, the possibility exists that higher average concentrations would have been observed if more stable wind conditions were present.

Dispersion modelling of the emissions from Canada Metals, based upon data obtained from stack sampling of the plant, indicate that ground level concentrations of SO_2 and H_2SO_4 mist could exceed the one hour guideline under certain conditions⁽¹⁰⁾ (see Appendix B).

A downwind location from the plant was determined by the comparison of wind direction and the compass bearing of the plant with respect to the monitoring site. This bearing, plus or minus 20° yields the direction range within which the receptor site is considered to be downwind of the source. This is only a generalization, however, and other factors, such as the distance from source to receptor, wind velocity and variability of the horizontal wind component will influence the range. For this study, the following ranges were used:

- i) Site #1 is downwind of the Canada Metals plant when the wind direction (hourly average) ranged between 210° and 250° (i.e. $230 \pm 20^\circ$)
- ii) Site #2 is downwind of the Canada Metals plant when the wind direction ranged between 150° and 190° .
- iii) Site #3 is downwind of the Canada Metals plant when the wind direction ranged between 130° and 170° .

CONCLUSIONS

Regarding the air quality measurements conducted during this study, it can be concluded that, under meteorological conditions similar to those experienced during this survey, Manitoba Air Quality Guidelines for Sulphur Dioxide could be exceeded, based upon a one hour time weighted average. While noting only exceedances of the Maximum Desirable Level, evidence exists indicating that the Maximum Acceptable Level could also be exceeded under certain conditions.

REFERENCES:

- (1) Georgi, H. W. 1970 Journal of Geophysical Resources, Volume 75, 2365-2371 as cited in "Review of National Ambient Air Quality Objectives for Sulphur Dioxide". 1982, Subcommittee on National Air Quality Objectives.
- (2) Amdur, M., Schulz, R., A. Arch Ind. Hyg, Occup Med., 5 (1952) p. 318.
- (3) NIOSH Manual of Analytical Methods, Volume 1, U.S. Department of Health, Education and Welfare, Public Health Service, 1977.
- (4) State of Missouri, 1972, Title 10 Section .010
- (5) Province of Ontario Regulation 308 (1982).
- (6) State of Pennsylvania. S.A.C. Title 25, Part 1, Subpart C Article III - Chapter 139.
- (7) Map for this study obtained from:
City of Winnipeg Planning Office.
- (8) Interstate Air Pollution Study Phase II Project Report Part IV; Effects the Air Pollution, U.S. Department of Health Education and Welfare, Public Health Service, 1966.
- (9) Lenardos, G.
Journal of the Air Pollution Control Association,
Volume 19, Number 2, 1969 p.91
- (10) Bennett, Mark Internal Communication dated October 20, 1984 to Dave Bezak, Head, Air Standards and Studies Section, Environmental Management Division.

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APPENDIX A

APPENDIX A:

Ambient Air Monitoring Sites

Site No. 1

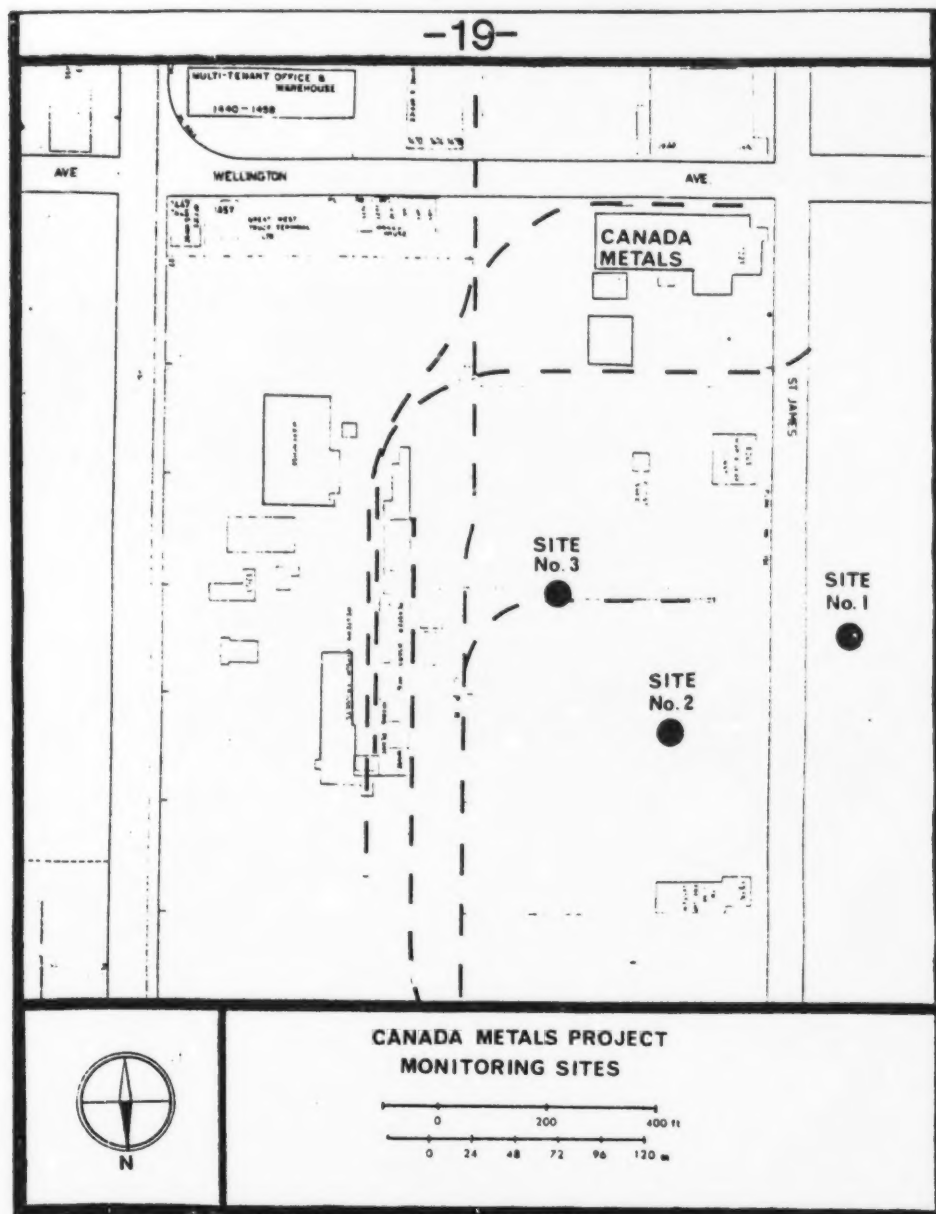
- Description: (a) Vacant Lot, West Side of St. James St.
(b) Approximately 250 m North of Wellington Ave.
(c) Approximately 10 m West of St. James St.

Site No. 2

- Description: (a) Triline Freight Yard.
(b) Approximately 20 m East of St. James St.
(c) Approximately 200 metres from Canada Metals Plant.

Site No. 3

- Description: (a) Triline Freight Yard.
(b) Approximately 40 m East of St. James St.
(c) Approximately 150 metres from Canada Metals Plant.



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APPENDIX B

October 10, 1984

- 1) Dave Bezak, Head,
Air Standards and Studies.
- 2) File

Mark Bennett,
Environment Officer,
Air Standards and Studies.

DISPERSION MODELLING FOR CANADA METALS

Run of program PNT1, a point source ^{Garrison} dispersion model, employing the plume formula to estimate ground level plume centreline concentrations of a (passive) gaseous pollutant emitted from an elevated stack. Model developed by R.V. Portelli, Atmospheric Dispersion Division.

Most of the input parameters (stack height, diameter, gas exit velocity, and temperature) were obtained from an E.C.S. report titled, "Source Emission Testing for Sulphur Dioxide and Sulphuric Acid Mist at Canada Metal Co. Ltd, Winnipeg, Manitoba, 1982" (see file 506). Pollutant emission rate (gm/s) was also obtained from the same report. The value used was the highest single test result (for SO₂) and not the average, thus simulating "worst case" conditions. The input value for ambient temp. was taken as Standard conditions, i.e., 298 OK (25 °C).

The first run of the model involved the use of Briggs Urban coefficients which take into account the effects on dispersion of neighbouring buildings and other tall structures which would (as a rule) tend to increase turbulence and thus lead to greater downwind dispersion.

The model generates values for concentration in (micrograms per cubic metre, µg/m³) at specified downwind distances (km) VS. specified wind speeds (m/sec.). This is done for each of the Stability classes (A to F). Special note should be made that stability class D (often regarded as a default value in the absence of other information) actually occurs (on average) over 1/4 the days, and C and D together represent about 80% of conditions, on average.

The following predictions were evident from the 1st run of the model (recall that this involved Briggs Urban Coefficients).

I SO₂ (Stability Class D)

1. The air quality objective for SO₂ would not be exceeded at any distance greater than 300 m., and at less than 300 m only with low wind vel.
2. No excess levels would be anticipated at any distance when wind velocities are greater than 5 m/sec.
3. For stability class C the objective would be exceeded at 100 m from source with wind velocities ranging from 3.0 - 11.0 in m/sec.

4. Potentially no excesses would occur beyond 300 metres (Class C) and then (at distances under 300 m) only with low velocity winds, 2.0 m/sec.

II. H_2SO_4 Mist

Regarding sulphuric acid mist a few points should be noted. All input parameters remain the same except for the emission rate. This again is obtained from the report quoted previously. Here again we use the highest test value and not the average so that we may simulate "worst case" conditions. The emission rate is 19.0 kg/hr. or 5.3 gm/sec. The predicted concentrations will be directly proportional (1 to 1) to this variation in emission rates.

Due to the hygroscopic nature of H_2SO_4 mist, the potential for drplet growth, depending on humidity, is a real possibility. Therefore, assuming homogeneity of the plume requires a little more latitude.

1. For stability class D the proposed guideline of $100 \mu g/m^3$ would be exceeded at distances up to between 500 - 800 m. at low wind velocities (2.0 m/sec).
2. The level could be exceeded at higher velocities and shorter distances with the following limits; 3.0 m/s to a distance of 500 m. 4.0 - 7.0 m/sec. to a distance of 300 m, 8.0 - 20 m/sec. to a distance of 100 m.
3. For stability class C the following limits are apparent; for a wind velocity of 2.0 - 3.0 m/sec. the distance of estimated excess levels would be up to 300 m, 4.0 - 20.0 m/sec. to a distance of 100 m.

The second model run is to simulate "rural" conditions or those where there would be no other adjacent structures which would cause a perturbation of normal dispersion. The following predictions were evident from the 2nd run of the model (no Briggs Urban Coefficients used).

1. Stability class D, at low wind velocities 2.0 - 4.0 m/sec. the guideline level may be exceeded at distances up to between 1.0 to 2.0 km (for wind speed = 2.0) and 1.0 km for wind speed of 4.0 m/sec., at a wind speed of 5.0 m/sec. excess levels may be found at up to 800 m., at velocities of 6.0 - 10.0 m/sec. the maximum range of anticipated exceedances is 500 m., and at a wind speed of 10.0 - 14.0 m/sec. to a distance of 300 m. There would be no exceedances at 100 m distance with wind velocities below 21.0 m/sec.
2. Stability class C at a velocity of 2.0 m/sec. the maximum distance would be between 800 m and 1.0 km., at speeds of 3.0 - 6.0 m/sec. the distance would be 500 m., at velocities of 7.0 - 13.0 m/sec. the distance would be about 300 metres. As with class D there would be no exceedances at 100 m. distance with wind velocities below 21.0 m/sec.

SO_2

1. Stability class D, the only time that levels would exceed the objective level would be with wind velocity at 3.0 - 4.0 m/sec. and at a distance of about 300 - 800 metres.
2. Stability class C, at low velocity 2.0 - 3.0 m/sec., a downwind area about 300 - 500 metres from the source would experience SO_2 levels in excess of the objective, and at velocities from 4.0 - 7.0 m/sec. excess levels would be found around the 300 m distance.

In my opinion, the actual conditions around Canada Metal would be best described as something between an urban and rural venue.

As you know some ambient monitoring has been performed in the vicinity of Canada Metals. In comparing actual results with modelled estimates a couple of interesting occurrences were noted. We have no way of confirming our position of monitoring via a vis the plume centreline but interestingly on the occasion of our highest 1-hr. ambient SO_2 reading of 648 ug/m^3 the model prediction is 653 ug/m^3 (given the input parameters stated previously which may or may not be correct). Another reading of 432 ug/m^3 occurred when the model predicted 392 ug/m^3 .

On the majority of occasions, however, our actual readings were well below the model estimates. My guess is that this indicates that we were probably not on (or near) the plume centreline at these times.

We are currently investigating the costs and availabilities of ambient temperature sensing equipment which can provide increased accuracy in input parameters for future modelling exercises.

SUMMARY

1. The model predicts that ground level concentrations of both SO_2 and H_2SO_4 mist, will under certain conditions exceed guidelines (objective) levels for 1-hr. concentrations.
2. The excesses of H_2SO_4 would probably occur in greater numbers and over greater distances than SO_2 .
3. SO_2 levels would not likely exceed the guideline at distances greater than about .5 km and H_2SO_4 would not likely exceed the guideline at distances greater than about 1 km/

The summarized conclusions above refer only to neutral and slightly unstable cases (stability classes D and C respectively). Changes in input parameters will obviously result in changes in predictions.